DUAL AXIS SOLAR TRACKER STUDY

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ABSTRAK

Analisis untuk pengesan solar dua hala akan dilaksanakan. Dalam pengembangan teknologi yang tinggi pada masa kini, teknologi pengesan solar dua hala tidak diimplementasikan dengan sepenuhnya. Satu lagi solar sistem yang dipanggil pengesan solar satu hala pula jauh lebih popular dan digunakan secara luas. Namun begitu, pengesan solar satu hala mempunyai keberkesanan yang rendah. Justeru, analisi untuk pengesan solar dua hala akan dilaksanakan untuk mengambil alih penggunaan pengesan solar satu hala yang tidak berksan. Cara untuk menguji prestasi sistem pengesan yang dianalisis adalah dengan menggunakan satu alat pengesan solar untuk menguji samada pancaran dari matahari adalah mengarah kepada permukaan pengesan solar tersebut atau tidak dengan menggunakan pengiraan secara matematik bagi sudut azimuth dan sudut zenith. Satu simulasi menggunakan Borland C++ Builder akan direka untuk menunjukkan proses dan langkah untuk menjalankan satu pengesan solar dua hala. Pada akhir projek ini, ia adalah dijangkakan bahawa sudut azimuth-zenith yang dikira adalah tepat pada mana-mana tempat dan bila-bila masa.

ABSTRACT

An analysis for a dual axis solar tracking study is to be carried out. In the current growth of technology, the technology of this dual axis solar tracking system has not been fully utilized. The other solar power system called single axis solar power system is much more popular and widely used. However, single axis solar tracking system has a very low efficiency, yet it is not cost effective. Therefore, the analysis of dual axis solar tracking system is to be carried out to take over the inefficient single axis solar tracking system. An independent method will be used in order to evaluate the performance of the proposed tracking system. It is by practically using a dummy solar tracker to test whether the reflection of the sun is accurately towards the target point at any given time according to the mathematical calculation of the elevation and azimuth angles of the sun. A simulation using Borland C++ Builder will be created to simulate the processes and the steps to operating a real dual axis solar tracker. At the end of this project, it is expected that the azimuth-elevation angles calculated are precise and accurate at any place and time.

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δ	-	The declination of the Earth
ϕ	-	Latitude
N	-	The day number, i.e. counted from January first
H	-	The hour angle
α	-	Elevation angle
θ	-	Azimuth angle
X	-	Deviation angle
λ	-	Longitude
t_s	-	Solar time
t_c	-	Civil time
ΔT	-	Difference between civil and solar time

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In this technologically based world, electric power plays the sole role of providing energy for the operations of machines, either commercial based or industrial based. However, the generation of electricity often leads to environmental destruction. It is related with aspects as deforestation control, protection of ozone layer, reduction of CO_2 emissions and others. The environmental issues are now being regarded as the most crucial problem. Therefore, the goal of obtaining good energy supplies of electric power is to be emphasized. According to that goal and considering additionally the exhaustion of the energy reserves and the global heating of the planet to promote and improve systems sourced with renewable energies is a must. A good energy source prospect for industrial continuous processes needs to be: more or less constant energy throughout the year; highly reliable and needs little maintenance; low cost to build and operate; virtually no environmental impact; modular and thus flexible in terms of size and applications; landscape friendly. A solar electric system-also known as photovoltaic (PV) systems—fulfils this entire characteristic.

1.2 DESIGN OBJECTIVE

The objectives of this project are to prove the azimuth-elevation concept in dual axis solar tracker and to develop a simulation of the dual axis solar tracker using Borland C++ Builder.

The aim of this dual axis solar tracker study is to prove that the accuracy and consistency of the sun tracking is much more efficient compared to other solar tracking systems such as single axis tracker.

The accuracy of the dual axis solar tracker will be proved by using a dummy solar panel. The dummy solar panel will be controlled according to the azimuth-elevation angles calculated.

1.3 SCOPE OF PROJECT

In this project, the dual axis solar tracker is based on an opened-loop system where the tracker operates according to the sun's geometry and does not have any feedback from the output to the input. The main goal is to prove the operation and efficiency of the solar tracker which operates according to mathematics calculation on the sun geometry.

The scope of this project is:

I. Construct a dummy panel to prove the perpendicularity between the sunlight and the panel.
II. Develop an simulation program by using Borland C++ Builder software.

The limitation of this project is the dummy panel will not be interfaced with the software which controls the rotation and elevation of the solar tracker. The significance of the dummy panel is merely to prove the perpendicularity of the solar tracker with the sunlight. It does not prioritize on design or does not involve any controller. It is merely constructed to obtain the desired angle according to the mathematical equations of the azimuth-elevation angles for the dual axis solar tracker.

The software developed is merely to simulate the dual axis solar tracker's operation. It does not prioritize on design or algorithm of the software. It is not a new program and does not concern about the creativity or feasibility of the algorithm other than to simulate the dual axis solar tracker's operation.

1.4 SIGNIFICANCE OF STUDY

This project is carried out to prove the mathematics equations on the sun's geometry where the solar tracker's movement based on the sun's geometry has a high efficiency which completely eliminates the cosine effects which is the main deficiency in photovoltaic system. The solar power system, especially photovoltaic in Malaysia is still under used because of low efficiency. This is because more than 90% of the photovoltaic systems in Malaysia are standalone systems which use standalone solar panels. Some of the photovoltaic systems use single axis tracker, but still does not emit high output efficiency. The dual axis solar tracker is a powerful alternative for the photovoltaic system. It completely eliminates the cosine effect of the photovoltaic system and significantly raised the efficiency of the photovoltaic system. It is better than a single axis solar tracker since the sun geometry involves two axes, which are azimuth and elevation angles. Furthermore, dual axis solar tracking system increases the average working hours for photovoltaic system. For a normal standalone photovoltaic, the average working hours are 4-5 hours per day. With dual axis solar tracking system, the average working hours will be increased to at least 7-8 hours per day. Therefore, it is absolutely necessary to carry out this project to promote the application and utilize the dual axis solar tracker in Malaysia.

1.5 THESIS OVERVIEW

This thesis is primarily concerned with the analysis and simulation of the dual axis solar tracker. All the work done in this project is presented in 7 chapters:

Chapter 2 outlines the literature review studied in order to understand the difference between dual axis solar tracking systems compared to other photovoltaic systems such as standalone system. This is important in order to make sure that this project is worth-while to be carried out.

Chapter 3 outlines the methodology used in the implementation of the project. This chapter includes the flow of the project development and the flow of the programming used in the project. This is one of the most essential part of the project as it determines the whether the flow of the project is smooth or otherwise.

Chapter 4 outlines the results of the output for the dummy solar axis tracker. An analysis on the efficiency of the azimuth-elevation will be implemented. This is important to determine whether the objective of this project is achieved or not.

Chapter 5 summarizes the overall project design and its future development.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Human beings are faced with oil and coal depletion of fossil fuels such as a serious threat that these fossil fuels is a one-time non-renewable resources, limited reserves and a large amount of combustion of carbon dioxide, causing the Earth's warming, deterioration of the ecological environment. With the development of society, energy saving and environmental protection has become a topical issue.

The green energy also called the regeneration energy, has gained much attention nowadays. Green energy can be recycled, much like solar energy, water power, wind power, biomass energy, terrestrial heat, temperature difference of sea, sea waves, morning and evening tides, etc [1, 2]. Among these, solar energy is the most powerful resource that can be used to generate power. A good energy source prospect for industrial continuous processes needs to be:

• More or less constant energy throughout the year;

- Highly reliable and needs little maintenance;
- Low cost to build and operate;
- Virtually no environmental impact;
- Modular and thus flexible in terms of size and applications;
- Landscape friendly.

2.2 PHOTOVOLTAIC SYSTEMS

Solar electric systems—also known as photovoltaic (PV) systems—fulfils all of this characteristics [3], so far the efficiency of generating power from solar energy is relatively low. Thus, increasing the efficiency of generating power of solar energy is very important.

As a new type of solar energy, which has unlimited reserves, widespread in the world, the use of economic advantages, so the sun energy using is in the rapid development and application. However, solar energy has some disadvantage, such as: the existence of low-density, intermittent, changing the spatial distribution, so all the defects make the current series of solar energy equipment, such as solar water heaters, solar cells, in the low utilization rate. The sun is moving all the time, no matter what kind of solar energy equipment, if it's part of the energy conversion to always keep vertical with the light, it can be used in a limited area to collect more solar energy. In order to maintain the equipment, solar energy conversion and some of the vertical sunlight, it is necessary to track the sun, and the sun automatic tracking device maybe resolve this issue. The professor of KPCheung and SCMHui form University of Hong Kong's Department of Architecture study the relation between the sun angle and receiving rate. The theoretical analysis shows that: the sun-tracking or not, energy receiving rate difference is about 37.7%[4, 5, 6, 7, 8].

In the past, solar cells have been hooked with fixed elevating angles. They do not track the sun and therefore, the efficiency of power generation is low. For example, the elevating angle of a solar cell for the largest volume of illumination in daytime is 23.5°in southern Taiwan. Since the fixed-type solar panel cannot obtain the optimal solar energy, the transformation efficiency of solar energy is limited. In order to have an approximately constant energy production throughout the day, it is necessary that the photovoltaic panels changes its orientation throughout the day following the path of the sun in the sky, this is possible by means of an automatic solar tracker system. A solar tracker improves the efficiency of solar electric o thermal energy conversion system [9]. Many scholars have proposed different methods for tracking the sun [10, 11, 12, 13, 14, 15]. Many different light source sensors, light intensity sensors, intelligent vision techniques, and CCD equipments were applied to compute the absorbed time of the sun radiation in everyday for measuring the volume of solar energy. So far the majority of solar cell panels worldwide are hooked with fixed angles. Thus, it is clear that the method of tracking the sun is a technique worthy of being developed.

Most PV installations in Malaysia so far are standalone systems. Grid-connected PV started with some test installations recently. The “Prototype Solar House” located near Kuala Lumpur was built in 2002 as part of an Industry Research and development Grant Scheme (IGS) project. It is unique, since in a typical residential house 3 different grid-connected roof installation with different PV generators (polycrystalline, monocrystalline, amorphous silicon; standard mounting, integration, roof tiles) have been built with emphasis also on architecture and thermal aspects. An innovative monitoring system allows assessing all relevant operating parameters for the PV systems. The installations run very reliable with high efficiency, but some grid specific aspects have been found relevant for proper functioning of grid-connected PV systems in

Malaysia. Until now, most applications of PV technology in Malaysia are concentrating on stand-alone systems. Because Malaysia is located just north of the Equator, there is a high annual irradiation and simulation calculations lead to an expected AC energy output for ideally orientated grid-connected PV systems of around 1200 ... 1300 kWh/kWp [16].

The high one-axis and two-axis tracker penetration in large scale PV power plants is due to the fact that sun tracking systems substantially improve the daily energy production of flat plate modules. Indeed, the energy gain is nearly 28 % in middle Europe [17] and even more than 50 % in north Europe [18]. Therefore, if keeping the mechanical costs acceptable, solar trackers represent an interesting possibility to increase the energy yield of conventional solar power plants without increasing the installed power capacity. As it is shown in Figure 1, one or two axis solar trackers already represent 27 % of the total power plant capacity worldwide in 2008 [19]. This part is increasing constantly since the additional costs for the mechanics are still inexpensive compared to PV.

The solar cell is composed of the semiconductors of the P-N junctions [20-21]. It can convert light into electric energy. Therefore we can assume that electricity produced using sunlight shining on the solar cell can be used like common electricity.

Solar trackers main classification is: passive and active. Passive trackers use a low boiling point compressed gas fluid heated by solar energy that is driven to one side or the other by differential gas pressure which causes the PV array to rotate in response to its imbalance. Active trackers use electric actuators (motors and gear trains) to move the PV array commanded by a controller responding to the solar orientation. Solar trackers may be single axis (passive or active) or dual axis (only active). Single axis trackers usually have a manual elevation (axis tilt) adjustment on a second axis which is tuning throughout the year; both are shown in Figure 2.1 and 2.2 [22].

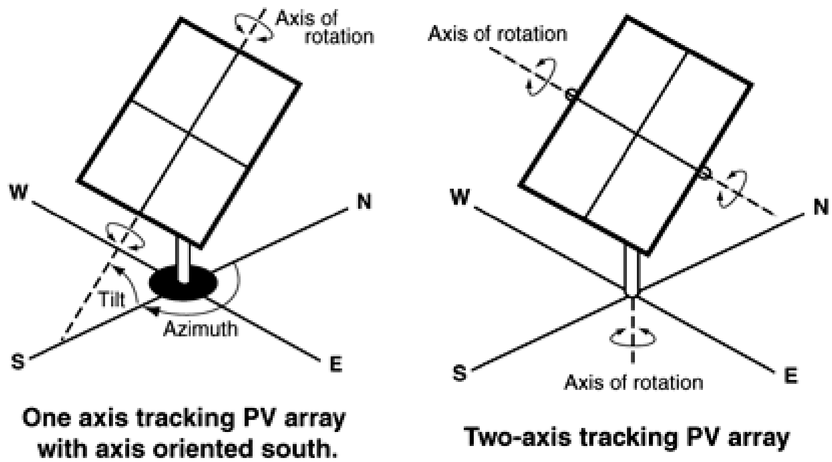

Figure 2.1: One and two axis tracking PV array

The design of tracker was based on the following criterions:

- Low cost;
- Easy maintenance;
- Modular;
- Fulfil technical specifications;
- Easy adjustment in case of different location.

Technical specifications were obtained considering similar commercial equipment [23] and that the installation of the PV array experimental facilities is in Cuernavaca, Mor., they are:

- Automatic interval of daily sun tracking rotation angle of 130º;
- Interval of year tilting angle of 47º (Figure 2);
- Secure operation and maintain position in winds of until of 120 km/h;